DOCUMENT RESUME

ED 048 895 LI 002 696

AUTHOR	Licklider, J. C. R.; And Others
TITLE	A Report of the Office of Science and Technology Ad Hoc Panel on Scientific and Technical Communications.
INSTITUTION	Office of Science and Technology, Washington, D.C.
PUB DATE	8 Feb 65
NOTE	41p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	Communication (Thought Transfer), *Government Role, *Information Dissemination, *Information Needs, *Information Networks, *Information Systems, Libraries, National Libraries, Scientists
IDENTIFIERS	Office of Science and Technology, OST, *Scientific and Technical Information

ABSTRACT

The context of this study includes: (1) the Government's arrangements to facilitate the flow of scientific and technical information, (2) the vast but amorphous "usership" of information in government, industry, the universities, and the public, and (3) the rapidly advancing technology of information. The purpose was to examine and assess the situation in, and trend of, scientific and technical communication and to give a progress report and an evaluation. The main broad impressions of the situation and trend in scientific and technical communication are: (1) The information problem is different from other problems of concern to the Office of Science and Technology (OST); (2) Fair progress is being made toward implementation of mechanisms to facilitate use of information; (3) The Committee on Scientific and Technical Information (COSATI) is doing almost all that can be done by a committee representing diverse agencies; (4) The government is only partially successful in getting non-government cooperation from a unified information system; (5) The demand for a unified system is increasing progressively from some quarters; (6) The field is not yet well enough defined to justify a national system attempt, and (7) The situation calls for a coherent plan and strong leadership. (This is considered to be one of the basic papers of government interest in the field of information science.) (Author/NH)

Appropriate Bibliographic Reference:
Licklider, J.C.R., et al. A Report of the Office of Science and Technology Ad Hoc Panel on Scientific and Technical Communications. 8 February, 1965. 21 pp. plus 3 appendices.

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REPORT
of the
OFFICE OF SCIENCE AND TECHNOLOGY AD HOC PANEL
on
SCIENTIFIC AND TECHNICAL COMMUNICATIONS

8 February 1965

ED048895

INTRODUCTION

Our (the Panel's) deliberations were anchored in the thinking of the Baker Panel,[1] the Crawford Task Force,[2] and the Weinberg Panel.[3] We addressed again the same broad problems studied by those groups, but we concerned ourselves more with libraries than they did. The context of our study include (1) the Government's arrangements, developing under the aegis of the Federal Council for Science and Technology (FCST) and the Committee on Scientific and Technical Information (COSATI), to facilitate the flow of scientific and technical information, (2) the vast but amorphous "usership" of information in government, industry, the

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1/ W.O. Baker, et al, Improving the Availability of Scientific and Technical Information in the United States. Panel Report of the President's Science Advisory Committee, 7 Dec. 1958.

2/ J.H. Crawford, G. Abdian, W. Fazar, S. Passman, R.B. Stegmaier, Jr., and J. Stern, Scientific and Technical Communications in the Government. Task Force Report to the President's Special Assistant for Science and Technology, AD-299-545, April 1962.

3/ A.M. Weinberg, et al, Science, Government, and Information: The Responsibilities of the Technical Community and the Government in the Transfer of Information. Report of the President's Science Advisory Committee, 10 Jan. 1963.

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universities, and the public, and (3) the rapidly advancing technology of information. Our purpose was to examine and assess [redacted] the situation in, and the trend of, scientific and technical communication -- particularly from the point of view of the non-government scientists, but also from other points of view -- and to give [redacted] simultaneously a progress report and an evaluation.

It seems to us that a basic dilemma faces government in its efforts to improve scientific communication. The dilemma is that government has two very different kinds of administrative responsibility. On the one hand, government should take the initiative, develop policies and impose its authority within its own domain. On the other hand, when it seeks the co-operation of the private sector of science in the development of an integrated "system," it can only exhort, coax, and persuade.

"Management" seems to be much more concerned about the inadequacy of existing channels of communication than is the scientific community as a whole. The technological community, however, if the voice of the engineers is representative, does seem to lean toward the view of management. Management, by its very nature, emphasizes the power of organization and reaches for a "system" while the academic scientist, by and large, seems to be content to play it by ear, with a biological rather than a eugenic attitude toward evolution. He regards communication as an intrinsic part of the research process -- not merely as a means of retailing the substantive products of research -- and he is just as defensive about attempts to

constrain the ways in which he communicates as in the way he investigates. His attitude may be unreasonable but it is real.

Our main broad impressions of the situation and trend in scientific and technical communication are:

1. That the problem of information is different from other problems of concern to OST -- that it requires special handling. Information is a field of study in its own right, and there is an identifiable technology of information, but information and its technology are also a part of every other field. It will therefore take an unusual melding -- accomplishable under the urging of OST -- of public and private efforts and of substantive and methodological competences to rationalize the nation's handling of scientific and technical information.

2. That fair progress is being made toward implementation of mechanisms to facilitate use, by the government and its contractor community, of information generated by or for the government.

3. That COSATI is working hard and doing almost all that can be done by a committee representing diverse agencies of the government.

4. That the government is achieving only partial success in persuading the scientific community to cooperate in integrating public and private services into a unified system for scientific and technical communication.

5. That -- despite the fact that the scientific community is not convinced, and despite the fact that the proposals of national systems

that we have seen seem unrealistic -- from some quarters the demand for a unified system are progressively increasing.

6. That the field is not yet well enough defined to justify an attempt to design a national system at this time. One must first develop principles with respect to centralization and distribution of functions and must understand better the "real" needs of generators and users of scientific and technical information.

7. That the situation calls for a coherent plan and strong leadership.

RECOMMENDATIONS

Journals, Monographs, and Books vs. Source Reports

In the planning and implementation of the system for scientific and technical communication, proper weight should be given to the kinds of communication mediated by journals, monographs, and books. Most of the recently-initiated government activity in scientific and technical communication is oriented mainly toward what we may call "source reports" -- reports printed or duplicated by the research and development organizations that created the information reported, rather than by professional societies or firms that are primarily publishers of journals, monographs, or books. Government concentration on source reports may be justified on the ground that, since the government is responsible for bringing the reported information into being, the government should do what it can to

mitigate the confusion caused by the diversity of sources, formats, levels of quality, and degrees of proprietary and security restrictions.*/ Concentration on source reports may be (or may have been) justified, also, on the ground that the source-report literature is (or was) less well organized, from a librarian's point of view, than the literature published in journals, monographs, and books.

However, the pendulum may have swung too far, and a disproportionately large amount of money and effort may be being spent on arrangements for handling source reports and a disproportionately small amount on arrangements for handling journals, monographs, and books. The problems of libraries, and particularly the problem of developing systems of libraries extending down to the local level, should be given increased attention.

"Conspicuity"

From the point of view of a scientist or engineer in a university, in industry, or even in the government, the present government-devised arrangements for handling scientific and technical information do not stand out boldly and in clear relief, do not present themselves as a convenient and effective tool or as a well integrated and readily comprehended system. Indeed, they are neither well understood nor effectively used by

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*/ Not only source reports but also published proceedings of conferences have, by and large, those unhappy characteristics.

most scientists and engineers. The arrangements are too complex, too dispersed. To most users -- at least to most new users -- the system should present a conspicuous front door and simple rules for ringing the door bell. The conspicuous portal would serve as a receiving and switching point. A user very familiar with the internal workings of the system could enter, of course, at an inconspicuous side door -- at the door of the particular agency or information center that holds the information he wants. But close familiarity with its internal workings should not be a prerequisite for effective use of the system.

(The internal workings of the system should be simpler and better coordinated than they are, but that is not a necessary condition for "conspicuity" to users.)

Active Participation by Scientists and Engineers

As suggested in the recommendation of follow-on panels, it is essential for some of the scientists and engineers who generate and use scientific and technical information to participate actively in the work of the scientific and technical information system. The required participation is not merely to contribute in the usual way to the system's store of scientific and technical information, nor is it merely to make use of the system's facilities more often or more knowledgeably. The thing that is needed is a strong and continuing interaction between the over-all organizers of the system and the scientists and engineers who use the system, an interaction that will connect the working-level man's intimate

knowledge of the structure of his particular field with the system man's knowledge of informational techniques and system requirements. It will be difficult to establish that interaction, to make that connection. But it must be done. There is far too much subtlety and "technicality" in the scientific and technical literature -- and far too much literature -- for deep indexing, abstracting, etc., to be handled mainly by documentation specialists in Washington. On the other hand, substantive scientists and engineers, not interacting with specialists in documentation and bibliographic control, do not contribute the information that is required as the basis for effective systems of storage, organization, retrieval, and dissemination. The only solution that appears feasible now is to bring the grass roots of science and technology into the system, to attach the roots to the trunk of the information-system tree. We recommend that the effort to do that be given greatly increased emphasis.

Improvement of Technical Writing

One of the theses of the Weinberg Report[3/] is that scientific and technical communication suffers from poor writing, that style and exposition have deteriorated during the last several decades, and that something should be done about it. We realize that the writing habits of a large group are difficult to influence, that excellence of communication among men is hard to measure, and that mere admonition is futile. Nevertheless, we concur with the Weinberg Panel in wishing to encourage good writing, and we recommend four things:

a. Measurements of comprehension by readers, to determine whether scientific and technical exposition has actually deteriorated over the years and, if it has, how much.

b. Experiments with various styles and strategies of exposition to determine whether the variance in effectiveness of diverse styles and strategies is significantly large, and, if it is, to define rules or guidelines for effective scientific and technical writing.

c. Investigation of the extent to which the editorial policies of journals have imposed conventions that dehumanized the efforts of authors to communicate.

d. A coordinated "clamp-down" on government contractors who submit poorly written reports in partial fulfillment of their contractual obligations -- a clamp-down compelented by edict, admonition, example, and publicity (which might enhance the effect even though they would not do much good by themselves) and by an effort to get those upper-echelon government administrators of science and engineering who do appreciate the language to give more weight, in hiring, firing, promoting, and demoting, to the criterion of effectiveness in communication.

Explorations and Experiments

In our consensus, it is not the time, yet, to design a national system for scientific and technical communication. It is the time to start developing an over-all conceptual framework for a national system; a plan to guide

research and development. Moreover, it is time to build experimental or exploratory systems capable of handling actual problems and perhaps of growing or evolving into operational systems. Some of these experiments need to be conducted on a scale somewhat larger than the normal scale of research in the informational sciences. The explorations and experiments should deal with "real" information bases and with "real" users. Insofar as possible, the work should be controlled, monitored, and evaluated in the best tradition of experimentation.

DISCUSSION OF PROBLEMS AND ISSUES

On several other topics, the Panel arrived approximately at a meeting of minds, but stopped short of making definite recommendations. Brief discussions of those topics follow:

1. Specialized Technical Information Centers [3/]

The Weinberg Panel pinned great hopes on the concept of the Specialized Technical Information Center. The concept calls for a group, made up of scientists and/or engineers engaged in substantive work in a delimited field of science or technology, together with one or more experts in information science, to organize, evaluate, summarize, criticize, and disseminate the "literature" or "information base" of that field. The output of a Specialized Technical Information Center is bibliographic information plus abstracts and summaries plus reviews and criticisms plus "scientific intelligence" digests plus, perhaps, newsletters and loans or gifts of copies of documents. A Specialized Technical Information Center is associated

with an active laboratory or development agency, and most of the people who participate in the basic work of the Center do so in connection with their substantive work in research or engineering. We share in the Weinberg Panel's high regard for that concept. We have heard about several Centers that implement the concept well and that are very effective.

On the basis of our limited study of the situation, however, we are afraid that there are too many Specialized Technical Information Centers that have little more than a nominal connection with the Weinberg Panel's concept. Some of these have come into being because it has become "the thing to do" for a government agency that supports research in a given field to set up a Specialized Technical Information Center in that field. Indeed, if agency A does not hurry, agency B will set up the Center for the field in question.

There are now between 200 and 400 Centers for Specialized Technical Information. We are afraid that, in many of them, an excellent concept may be suffering from merely-nominal and low-quality implementation.

Our examination of this matter was not thorough enough to warrant a conclusion or a recommendation.

The main question is, are the outputs of the Centers of the quality on which important decisions in science, engineering, and government should be based?

2. Centralization and Distribution

In the context of proposed systems for scientific and technical communication, centralization is a controversial theme. We foresee the danger of losing the advantages of centralization in some functions unless thinking on the subject is sharpened -- unless it is recognized that a system can have some of its functions centralized and others distributed.

Centralization seems appropriate to us for the functions of standardization, monitoring of compatibility, and over-all planning, guidance, and evaluation. Centralization seems appropriate to us also for coordination of contributions from distributed sources, but the actual work of abstracting, synthesizing, organizing, and summarizing the literature should be distributed among professional societies, Specialized Technical Information Centers, and other organizations close to actual research and engineering. Interaction with individual scientists and engineees must be handled mainly, of course, by local and institutional libraries.

In our recommendation on "conspicuity" we tried to separate the function of "portal to the government's information system" from the various substantive service functions provided by the system, and to centralize the portal function without necessarily affecting the others.

Here, we advocate guidance and leadership, mainly from OST, to accelerate the definition and enforcement of standards for bibliographic formats and machine-readable representations of documents. To centralize authority, guidance, and leadership is, we are emphasizing, quite

different from setting up a huge central repository of documents and bringing many scientists, engineers, and information specialists to it to work on its contents. We favor the former. We are skeptical of the feasibility and the desirability of the latter.

We think that there may already be too much centralization of substantive effort, i.e., too much deep indexing and abstracting in libraries and documentation centers in the Washington area. Doubtless it is easier to handle the problem centrally, but we think the work would be done better if it were done in closer association with on-going research and development, and we think a system can be devised that will take advantage of the normal informational activities of working scientists and engineers and of the best Specialized Technical Information Centers. Centralized planning, guidance, and leadership will be required to make such a system work in an effective, coordinated way. The right amount and kind of standardization will be vital to its proper functioning. In short, we visualize a dynamic, continually improving system that is guided and coordinated from OST, yet that involves a manifold of interacting agencies and extends all the way into the "grass roots" of science and technology.

3. The "Real" Needs of Users

It is now widely recognized that an understanding of the needs of users of scientific and technical information is required as a basis for design of systems. The National Science Foundation has sponsored studies (e.g., 4/

by the American Psychological Association (APA) [4] and Columbia University [5] of the existing situation in the flow and use of scientific and technical information, and the Department of Defense has a major interview study under way [6]. Also, the National Institutes of Health have sponsored a study by the National Academy of Sciences-National Research Council of how research workers in biomedicine actually communicate [7]. Other studies have examined the communication process in the intelligence communities, and elsewhere. We are impressed favorably by those studies. At the same time, we feel that existing practice may be a poor source of information about the "real" needs of users.

In industry and universities, several exploratory, empirical studies have been (or are being) carried out -- studies in which storage, retrieval, and dissemination systems are set up and tested on groups of typical users,

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4/ W. D. Garvey and B. C. Griffith, Research Frontier: The APA Project on Scientific Information Exchange in Psychology. J. Counseling Psychol. 10, 297-302, 1963.

5/ P. Lazarsfeld, Telephone Communication, December 1963.

6/ W. Carlson, Personal Communication, December 1963.

7/ National Academy of Sciences-National Research Council, Communication Problems in Biomedical Research, Supplemental Report of Study for National Institutes of Health-Public Health Service, 10 March 1964.

then improved and tried again.[8/] Ingenious planning plus trial-and-error evolution is a better method, we think, than the interview.

Such studies require measurement and analysis of the performance of systems. Methods for measurement and analysis of performance are not well developed in the field of information systems. We therefore advocate intensification of work on those problems.

4. Effective Use of Computers

During the course of our study, we detected a tendency toward polarization of attitude toward machines that process information, particularly toward digital computers. The polarization seems to us to be potentially dangerous and costly. We should like to say a word, here, against it.

Some speak as though computers were going, all by themselves, to solve the problems of the "information explosion." (Indeed the phrase, "information explosion," tends to occur frequently in the context of computer magic.) Others, perhaps in over-reaction, tend to reject proposed applications of computers without taking time to understand them, and seem to consider it almost fraudulent to mention computers in the context of documents and libraries.

8/ C. W. Churchman, Personal Communication, December 1963.

Although we did not try to go deeply into problems of mechanization, it is clear to us that both the extreme attitudes are wrong. Computers have demonstrated usefulness in applications such as production of Index Medicus (The "MEDLARS" Project), 9/ but they extend no short-term promise of automating all the functions of a library, let alone a national system for scientific and technical communication. For a long time, we shall be dealing with systems that include men as well as machines. Certainly, the systems have to be planned and designed by men, and the computers have to be programmed by men. In short, computers offer no magical solutions, but they are potentially such useful tools it would be very wrong to fail to exploit them.

We hope that OST, FCST, COSATI, and all the other groups involved in planning and implementation of informational systems will hold to a middle course, that they will avoid the extremes of polarization of attitude. The "middle course" should include support of medium- and large-scale experiments to test the effectiveness of the most promising of proposed man-machine information systems. It should not exhaust the available funds on a single computer-based system, but neither should it divide all the funds into such small parcels that experimental systems of significant size and scope cannot be tested. This advocacy of medium-

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9/ National Library of Medicine, The MEDLARS STORY (Medical Literature Analysis and Retrieval System), Department of Health, Education, and Welfare, Public Health Service, 1963.

and large-scale experiments is not intended as a reaction against the small-scale explorations and experiments that make up the present research effort. It is, rather, a plea that, instead of jumping from small-scale research to very-large-scale system-building, we take a more gradual approach through an area of experimental development.

5. National Libraries and Local Libraries

Our examination of the national libraries was not thorough enough to leave us with a firm conclusion, but we have a strong impression: that in the life sciences the National Library of Medicine is developing in such a way as to serve as the central focus of a system of field-oriented libraries and activities, whereas in the natural and social sciences and in engineering the Library of Congress is serving as a traditional library, but is only slowly developing new ways to facilitate scientific and technical communication. (We do not have an adequate basis for placing the Library of the Department of Agriculture in the comparison.)

In our opinion, it is important that there be a national library (or national libraries) for the natural and social sciences and for engineering. If it should prove not to be feasible to get the Library of Congress to fulfill the role, then the role should be given to a National Library of Science and Technology. Certainly, it would simplify the organization chart in an important way if there were a National Library of Science and Technology in the Executive Branch. Wherever it is placed, a national library should be granted a large measure of autonomy.

6. Informal Communication

It is evident to many scientists and engineers that, in their work, informal communications are more frequent than formal communications and at least as important. The studies made by the American Psychological Association,[4/] mentioned earlier, emphasize the prevalence of telephone and face-to-face discussions, laboratory visits, technical meetings, and author-distributed preprints and attest to their advantage in timeliness over formal publications. It does not make much sense to speak of governmental control over the "invisible colleges," but it is evident that account must be taken of informal communication in over-all planning.

7. Review Articles and Monographs

We are impressed by the importance, in the dynamics of science and technology, of the processes that digest and interrelate the contents of original papers and organize the body of knowledge. We concur in the feeling, expressed by preceding Panels, that scientists and engineers can contribute as significantly through engaging in those processes as by working in the laboratory. With the idea of recommending definite action to encourage such contribution, we discussed at length the need for review articles and monographs, and what is needed to foster the publication of more and better reviews.

We did not reach a firm conclusion or recommendation on the subject. We all appreciate the importance of reviews. Several of us favor increased government support of both the preparation and the publication of reviews.

Others of us, noting that there already is much such support (e.g., through the Specialized Technical Information Centers) and that many reviews are, indeed, being written and printed,[10/] feel that we are not in a good position to make a definite recommendation.

8. Government Subsidy and the Publishing Industry

There is a serious problem in the area of government subsidy. The problem is, in essence, that three fundamental principles tend to conflict when they are applied:

(1) The government should, in the national interest, see to it that important scientific and technical information (that the government has paid to bring into being) is communicated to potential users. The only way to effect its communication, in many instances, is to publish the information. But, in many instances, the information is not of sufficiently wide interest for publication to pay for itself, let alone make a profit. Therefore, the government must in some instances subsidize publication.

(2) The government should not subsidize, selectively, one branch of an industry in such a way as to give it an advantage over a competing branch of the industry.

(3) The government should not influence the editorial policy of the free press.

10/ C. Fix, D. T. H. Campbell, and W. A. Creager, Some Characteristics of the Review Literature in Eight Fields of Science, Herner & Company, Washington, D. C., Report under NSF Purchase Order 64-510, 11 Mar. '64.

In our discussions with a group of representatives of the publishing industry, 11/ the position of the business publishers was developed in the following way:

a. The business publishers recognize the requirement that the government ensure the dissemination of certain information.

b. Some business publishers (in particular, those represented) do not wish to receive government subsidy on the ground that such subsidy would to some extent put the government in a position to influence editorial or publishing policy.

c. The business publishers do not object to government subsidy of non-profit or not-for-profit publishers that do not compete with for-profit publishers. By "do not compete," the business publishers appear to mean, "restrict themselves to non-profitable areas of publishing, such as the archive journal field."

d. However, in subsidizing publication of scientific and technical information, the government typically subsidizes organizations that do not so restrict themselves. In particular, many professional societies

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11/ 10 Jan. 1964 Robert Saltzstein, Counsel, Associated Business Publications. 18 Mar. 1964 John B. Babcock, Executive Vice President, Robert Saltzstein, Counsel, Associated Business Publications; William P. Winsor, Vice President, Reinhold Publishing Corp.; Raymond W. Barnett and John Callahan, McGraw-Hill Publishing Co.; Henry Swirner, Fairchild Publications; James Claar, American Aviation.

publish not only archive journals but also magazines that carry interpretations, news, and advertising. (Indeed, some archive journals carry some or all of those items.) Since it is the over-all professional society, rather than the archive journal, itself, that is the fiscal entity subsidized, the government's subsidy may be viewed as fostering a competing publication. The non-profit or not-for-profit competition is favored, additionally, by the tax structure, and is regarded as a threat by the for-profit press. The for-profit press objects.

The over-all problem impresses us as being difficult and serious. It was evident to us that we were not the proper group to try to solve the problem, but we found ourselves in a position in which it would have been inappropriate to ignore it. We therefore limited ourselves to talking with one group of representatives of the business press and trying to formulate the issue in such a way that it would be clear to the representatives of the business press and to ourselves as representatives of science and technology.

In stating the issue, we have not tried to evaluate the degrees of conflict or threat involved or to judge the validity of the principles. Obviously, in such a context, what seems minor to one man may seem major to another, and it would be as inappropriate for us to apply a scientist's meterstick to a business object as for a representative of the for-profit press to evaluate the importance to the government of dissemination of certain scientific information. Our conclusion, therefore, is

only that there is a fairly clear issue, that it should not be neglected, that it may not be possible to settle it to everyone's entire satisfaction, and that the group that tries to settle it will need to exert both negotiating ability and statesmanship.

The representatives of the business press with whom we talked expect to have further interaction with a successor Panel.

9. Security and Proprietary Considerations

The problems of security classification and proprietary restriction of publication we regarded as extremely important but far too involved for consideration by a short-term panel. These problems should be studied deeply by a continuing panel or subpanel.

William Baker
A. Lee Barrett
Alexander Bavelas
R. Keith Cannan
C. West Churchman
Verner Clapp
Walter M. Elsasser
Frederick Mosteller
Sidney Passman
Alvin M. Weinberg
J. Hilary Kelley, Executive Secretary
J. C. R. Licklider, Chairman

8 February 1965

APPENDIX I*

PROPOSED EXPLORATIONS AND EXPERIMENTS IN SCIENTIFIC AND TECHNICAL COMMUNICATION

The purposes of this Appendix are to discuss briefly the topic of exploration and experimentation in scientific and technical communication and to suggest a few explorations and experiments.

Exploration and Experimentation in Scientific and Technical Communication

As indicated in the body of the letter report, we think that it is now time for experimentation on a fairly large scale in several fields of scientific and technical communication. We favor rigorous experimentation wherever it is feasible. In dealing with most of the problems that we shall mention, however, it may be reasonable to settle for some compromise between rigorous experimentation and mere gaining of experience. In making the compromise, one should try to hold onto such basic tenets of experimental design as observation of comparable, representative samples under systematically varied treatment. We think that it will be possible to be fairly systematic in measuring the performance of certain techniques and systems. We are less sanguine about the feasibility of adequate

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*/ This Appendix is submitted by the chairman of the Panel; it does not purport to reflect consensus of the Panel.

sampling. Certainly it will not always be either possible or appropriate to employ the procedures of random sampling from well defined populations in selecting the objects (techniques, methods, systems) or the subjects (people) for study. Often (see next paragraph), one will wish to examine the best representative, rather than a typical representative, of a class of objects. We think that it will be necessary, if the experiments are to contribute effectively to the advancement of the art, to have the experimentation closely monitored, and to a considerable extent controlled, by a group (such as a continuing OST Panel) including experts in documentation and library science, operations research, experimental design and inferential statistics, digital computing, social psychology, and the substantive fields of science and engineering that are involved in the experiments. In short, lack of rigor will have to be compensated for by abundance of good judgment.

In most of the areas in which we advocate experimentation, it is possible to formulate two or three alternative, competitive techniques or methods for handling an important function. It is important, of course, that each competing technique or method be as nearly the best of its class as it is possible to achieve "best" in planning. After the alternatives have been formulated, experimentation may be mainly a matter of testing the techniques or methods with balance and impartiality in an appropriate context - of trying them out for a sufficient length of time to measure their effectiveness of performance and to discover their strong features and their weaknesses. In many instances, not just one comparison, but a succession of comparisons and redesigns, will be needed, with each redesign profiting from the preceding experience.

Insofar as possible, the experiments should be conducted with "real" information bases and "real" information users. However, the experimental information bases should not, as yet, cover all of science or all of technology. One should deal with small fields of science and engineering and with groups of perhaps 100 to 1000 users. One should work with fields that are relatively advanced in their understanding of documentation and information-processing techniques, and with users who are relatively advanced in awareness and interest. However, both the fields and the individual users should be substantively oriented; it would not be very helpful merely to find out how effectively techniques of information retrieval function in the hands of information specialists engaged in research on information retrieval.

Proposed Experiments

Dissemination of Documents

As mentioned in the body of the letter report, there have been, and continue to be, experimental assessments of various schemes for the dissemination of documents, or abstracts of documents, to individual scientists and engineers.

In one dissemination system called SDI (for Selective Dissemination of Information), each document received into the system is described on the basis of its content with the aid of a vocabulary of key words or "terms," and each user in the system is described on the basis of his research interests in the same vocabulary. SDI matches the document descriptions against the descriptions of users, and then, in the instance of each match that meets a specified criterion,

it sends an abstract of the document to the user. The main trouble with that scheme, when actually tried in one case, was that the users received too many abstracts. That difficulty could have been overcome by making the criterion for matching more rigorous.

In another dissemination system, called SASIDS (for Stochastic Adaptive Sequential Information Distribution System), each person in the system is a contributor as well as a recipient of abstracts. When a member reads an article that is of interest to him, he picks up the telephone and reads to the system an abstract of the article. The system then sends copies of the abstract to its members. Whether or not it sends a copy to a particular member depends upon a coefficient with two subscripts, one standing for him (the recipient) and the other for the member (the source) who originated the abstract. If the coefficient is greater than the cut-off value, the system sends the abstract -- otherwise it does not send the abstract -- to that particular potential recipient. Each member who does receive the abstract is required to feed back, into the system, a measure of the relevance of the abstract, or of the document itself, to him. If the relevance is high, the doubly-subscripted coefficient increases. If the relevance is low, the coefficient decreases. Each member has a "gain control" that operates upon the magnitudes of all his coefficients, increasing or decreasing the number of abstracts he receives. Thus the system adapts in a gross way to the general desire for information of each individual member and in a more subtle and selective way to his particular pattern of interest. His pattern of interest is apprehended in terms of its "closeness" to the interest patterns of the

other members of the system.

The schemes just described work fairly well, but not well enough to warrant general adoption. Obviously, there are many possible paradigms, each capable of existing in many different versions. Human judgment, based on existing knowledge, is not capable of selecting or designing the optimal system. We doubt that, if a group of experts were limited to one selection, it would come very near to selecting the best. On the other hand, if systems such as those described were devised and tested serially, it might take quite a few years to "evolve" a truly good one.

In the field of document dissemination, therefore, we advocate a carefully organized, parallel attack. One should devise and compare experimentally five or six dissemination systems, then redesign the best two or three and add two or three new ones, then compare those, etc. The program might require three or four iterations. Practical restrictions might dictate that each dissemination scheme be tested in only one or two research organizations, in which case there would be a "confounding" of qualities of the organizations with qualities of the dissemination schemes. Even so, it would be fairly clear, after each year of experimentation, which paradigms were better and which were worse, and what modifications should be made to the better ones to improve them. By the end of three or four years, one or two systems would have emerged as leader(s), and it (they) would be suitable for adoption by several research and development organizations. Moreover, it should begin to be clear, by that time, how to go

about devising document-dissemination systems for larger groupings of users than individual research laboratories.

Dissemination of Scientific and Technical "Intelligence"

Whereas dissemination of documents and the substantive information they contain is of interest mainly to working scientists and engineers, dissemination of information about what is going on in science and technology -- so-called scientific and technical "intelligence" -- is of interest also to planners, sponsors, managers, and coordinators. The problem of timeliness is even more crucial in the case of scientific and technical intelligence than it is in the case of substantive scientific and technical information, but the intelligence problem is less formidable when measured in terms of the volume of information to be handled.

The development of computer-based techniques for "managing" data has provided a combination of methodology and technology that should facilitate the interchange of scientific and technical intelligence among the members of a compact managerial group. Washington, D. C. has such groups, geographically compact but distributed among diverse agencies. They greatly need a mechanism that will tend to increase the coherence of their efforts. Thus the situation calls for one or more than one exploration in the use of advanced data-management techniques or systems in the coordination of research or development.

We have in mind, as the basis for such an exploration, a computer-processible information base ("data base"), located in the Washington, D. C., area and maintained physically either by a government or a commercial organization. The

sponsors, monitors, and managers of projects in the various government agencies concerned with the particular field or fields selected for study would communicate with the data base from typewriter terminals in their offices via TWX or Telex lines. Remote interrogation and up-dating of a data base is now a fairly routine matter, at least in the research and development world; no advanced engineering is involved in setting up the facility.

The proposed exploration would be an exploration into the use of such a facility for coordinative purposes. An entry would be made into the data base at each critical point during the life of each research and development project. Among the critical points would be, for example, the decision of an agency to support research or development in a particular area or on a particular problem, the receipt of a proposal, the acceptance or rejection of a proposal, each progress report, each technical publication, each revision of aim or plan, each formal test or acceptance of a hardware product, and, of course, completion or termination of each project. The entries would consist of identification of the type of event and enough detail to constitute a significant communication to users of the system. In the case of a report, for example, the entry would include an abstract as well as author, title, source organization, date, and descriptors. It might include, also, managerial evaluation, and it might be keyed to a schedule (e.g., PERT Chart), also contained in the data base.

Rules and conventions governing interrogation of the data base would have to be worked out, of course, as part of the exploratory experimentation. From a technical point of view, it is easy enough to make certain parts of the data base

accessible to some and not to others, and to respect even fairly elaborate rules governing changes and additions to the data base. It is not feasible, however, at the present time, to make an experimental system of the kind we propose absolutely proof against prying and tampering. At first the explorations should therefore be made with unclassified and nonsensitive information.

In the proposed exploration, the "vertical dimension" of the managerial process should be sampled and exercised: the system should be set up in such a way as to be useful to, and used by, various echelons of management. In the interest of the higher echelons, it should make provision for abstraction and summarization. At the same time, in the interest of the lower levels of management that are in intimate contact with the ongoing research and development, it should carry a considerable amount of detail and should permit day-to-day adjustment.

It would be interesting to extend the system to serve, in addition to the administrators and managers, the actual substantive workers within the government and organizations doing research and development under contract to the government. It is open to question, of course, whether communication between contractors and monitors should be handled by the coordinating system we have been discussing or by a separate system, but it is clear that such communication should take place within a system that facilitates access to plans, schedules, reports, and data.

In planning and designing the facility for the proposed exploration(s), one should not focus so strongly on the data base in the machine memory that he

loses sight of the need to facilitate communication among the people in the system. The two things -- communication between man and the data base and communication among men -- need to be melded into one, a system for communication among people with reference to a readily and jointly accessible compendium of information.

Organization of Selected Fields of Knowledge

The task of organizing the body of scientific and technical knowledge is ordinarily left, except for sporadic artificial stimulations, to the initiative of individual scientists and engineers or to individual research or development organizations. Once in a while, when for some reason a considerable fraction of the knowledge in a particular field of science or engineering happens to be concentrated in the hands of a single laboratory or institute, there is a deliberate attempt to organize and cofidy that knowledge. The series of volumes on radar technology, prepared by the staff of the Radiation Laboratory of M. I. T. and published by McGraw-Hill Book Company at the close of World War II, is an example of deliberate organization and recording of the corpus of a field of knowledge.

An interesting way to foster advances in scientific and technical communication, and at the same time to improve the availability and usefulness of knowledge in a selected field of science or engineering, would be to inspire and support an effort to bring to bear, on the organization and codification of the knowledge of a selected field, all the promising tools that the science and technology of

information have to offer. The effort would require a team, made up mainly of substantive scientists or engineers of the selected field, but including also a specialist in documentation and library science and a specialist in information-processing technology. The project should have a definite focus, such as the preparation of a handbook or a volume of theoretical syntheses, or such as the conversion of the solid data of a field of knowledge into machine-processable form and the organization of the converted data into a useful data base. With such a data base, one could begin to represent the main theoretical structures of the field in terms of computer-program models and to intercompare and evaluate the models by determining their compatibility with the data of the data base.

Having a team try to organize the knowledge of a selected field of science or technology -- or having two or three teams try to do it for two or three fields -- does not in itself constitute an experiment or even an exploration. However, the teams -- there should be more than one -- and their efforts would constitute objects for observation and study. The teams would make interesting demands upon the Specialized Technical Information Centers in their areas. It would be possible to observe and record their requests for information, and the degrees of success with which their requests are met. The teams would try out, and use or discard, various information-processing techniques, and it would be possible to observe the degree of effectiveness of the techniques adopted, and find out why the rejected techniques were discarded. If the teams were successful -- if they enjoyed their work and developed interesting and useful products -- the attention of scientists and engineers in neighboring areas would be attracted to the improved techniques for organizing knowledge.

Bibliographic Control of Selected Fields of Knowledge

Let us refer to indexes, lists of descriptors, abstracts, catalogs, accession lists, and the like as the "apparatus of bibliographic control." The general purpose of the apparatus of bibliographic control is, not to convey substantive scientific or technical information, but merely to lead the would-be or should-be user to it. At present, it is costly and time-consuming to prepare effective apparatus of bibliographic control. Even the best apparatus fails to penetrate deeply into the structure and substance of its field of knowledge.

The large agencies and organizations charged with development and maintenance of the apparatus of bibliographic control are trying to do a job that is almost impossible to handle with present methods. The task is so difficult and demanding that they cannot devote much effort to the development of new methods to improve their capabilities. Small research projects, on the other hand, are not likely to develop the necessary techniques because small projects cannot work with information bases of significant size. We think that the problem of bibliographic control should be attacked on a middle scale. Exploratory or experimental tasks of significant size should be undertaken, but not tasks of overwhelming size. A few subfields of science and engineering should be selected, and within these subfields every effort should be made, and every promising technique should be tried, to produce timely and effective indexes, catalogs, abstracts, retrieval systems, and the like.

As we indicated in the body of our letter report, we believe that it is necessary -- if the apparatus of bibliographic control is to discriminate sensitively

among scientific and technical meanings of the ideas expressed by scientists and engineers -- to bring working scientists and engineers into the effort of creating and up-dating the apparatus. Explorations of the kind proposed here should therefore involve the technical committees or special-interest groups of professional societies. The explorations should thus be, in part, explorations in the melding of substantive science and engineering with library science and informational technology.

Such a melding will not take place of its own accord on a short enough time scale to make the proposed explorations productive. The first part of the effort, therefore, will have to concentrate on fostering active cooperation and participation by the substantive scientists and engineers. That will require a working group of the type that could be commissioned by a continuing Panel on Scientific and Technical Communication. In short, the first part of the enterprise has to be an exercise in social engineering, for a considerable amount of attitude changing and habit reformation are required to provide a favorable climate for improvement of scientific and technical communication.

The involvement of working scientists and engineers -- to which we have referred in the discussion thus far -- is involvement in the development, production, and maintenance of the apparatus of bibliographic control. The exploration would be incomplete if it did not involve working scientists and engineers, also, in effective use of the apparatus. We would look to the same technical committees and special-interest groups to contribute significantly to

the effective use of the apparatus. They might, themselves, operate dissemination systems. They should have close associations with the libraries and documentation centers in their fields, and with the information retrieval mechanisms operated by government agencies, and with the appropriate Specialized Technical Information Centers. They should foster the education of their colleagues in the use of the apparatus of bibliographic control, and they should see to it that the appropriate parts of the apparatus are built into the journals published by the professional societies.

The foregoing suggestions propose an exploratory experiment in approximately the same sense as do the suggestions made in the preceding section of this Appendix. The idea is not merely to set up and support a few activities in bibliographic control. It is to observe them carefully, to see which strategies and techniques succeed and which fail, and to distill, record, and exploit the knowledge thus gained.

Analysis of Specialized Technical Information Centers

In the body of the letter report, we suggested that a continuing Panel should assess the performance of Specialized Technical Information Centers. The following develops that suggestion a step further, but it leaves much thinking and evaluation to be done.

The various Specialized Technical Information Centers may be described in terms of attributes. If sufficient thought were put into the formulation of a list of appropriate attributes, one might be able to characterize each Center by

assigning it a value for each attribute. Doubtless there would be a strong subjective element in the determination of the values, but values could be determined and assigned.

The Specialized Technical Information Centers perform various functions. Although not all Centers perform precisely the same functions, one could prepare a list of functions that would cover most of the Centers, and one could devise measures of the effectiveness of performance of each function. (It would suffice to mark "does not apply" in each instance in which a Center does not perform a particular function.)

The proposed analysis is simply to characterize the Specialised Technical Information Centers carefully and in detail, then to measure their performance of the various functions, and then to determine what patterns of characteristics are associated with good performance. As acknowledged, there are many intangibles. In many places judgment will have to be substituted for objective measurement. Analysis of the data, once they have been obtained, will be a fairly complex undertaking. Nevertheless, we believe that a worthwhile analysis can be made. The performance data will be significant in and of themselves, and they should lead, through a simple feedback effect, to improvement of the Specialized Technical Information Centers. Moreover, the results might prove or disprove some important beliefs about how Specialized Technical Information Centers should be set up and operated. For example, one of the attributes examined in the analysis should be the signifiance of the scientific or technical attainments of the Director of the Center. There should be related attributes

for other principal members of the staff. Another attribute should measure the qualifications of the Director in the field of documentation and library science. The analysis, then, should confirm or refute the belief that one of the primary requirements for a successful Center is that it have a leading scientist or engineer at its helm. Similarly, the analysis should reveal whether it is essential to have the Center associated with an active laboratory or development organization. And so on.

Collection and Assessment of Techniques for Processing Information

During the last few years, literally hundreds of techniques for machine processing of library and bibliographic information have been developed or prepared. Most of these techniques are in the form of digital computer programs. Unfortunately, they have been written in diverse languages for various machines, and no considerable fraction of them is currently in use in any library or documentation center. This is not to say that the main governmental documentation centers do not have computer programs for handling their standard operations. Rather, it is to assert that the standard operations are not always as advanced as they could be, and that some of the most advanced techniques are not truly available for widespread application, either in research or in operations. For example, little or no actual use is made in libraries or documentation centers of analysis by computer of the actual text of technical documents.

We think that it is time for an effort to bring together and assess the techniques of information processing by computer that have shown promise in

laboratory experiments and in military applications. At the very least, it would be desirable to survey the techniques and to estimate the magnitude of the task of expressing the promising ones into a common language. If the project were carried through, it might become evident that machine techniques are capable, even now, of producing important parts of the apparatus of bibliographic control. Economic feasibility is of course a different matter from technical capability, but it is nevertheless important to achieve an improved organization and display of the technical capabilities.

APPENDIX II

TWO SUGGESTIONS CONCERNING GOVERNMENT SUBSIDY AND THE "FOR PROFIT" PRESS

Two suggestions, made by individual members of the Panel too late for development of Panel-wide consensus, are recorded here.

J. Hilary Kelley suggested that it might come close to meeting the needs and desires of both publishers and government if government support were limited to important articles, monographs, and the like that would have relatively small readership. That plan would let the government ensure the publication of documents it judged to require publication and, at the same time, would reduce the publisher's concern over unfair competition.

Frederick Mosteller suggested: "... perhaps the Internal Revenue Service's proposed change in tax regulations for revenue-producing advertising and non-member subscriptions in publications of non-profit organizations would go a long way toward solving the problem. According to MacDougall (A. Kent MacDougall, "Tax exempt or not?" Wall Street Journal, Friday, July 24, 1964, page 1, column 8), IRS officials are planning by the end of the year to alter the tax-free status of magazines and periodicals with respect to these income-bearing items, a move supported and campaigned for by Associated Business Publishers. Clearly, taxing these advertisements and memberships would reduce the revenue of the non-profit organizations, and requests for further government subsidy by the non-profit organizations would be bound to rise. The article estimates that about 57% of the American Medical Association's income of $22.5 million comes from these tax-free sources now under review by IRS."

APPENDIX III*

THE CONCEPT OF "NATIONAL LIBRARY"

In the traditional concept of "library," the principal functions are the repository function, the circulation function, and the development and maintenance of catalogues and indexes for bibliographic control. The first two functions deal mainly with documents -- the physical carriers of information and knowledge -- and not with the facts and ideas the documents contain. The third function deals with contents, but only to the extent of indicating in a few short terms what the documents are about, and not to the extent of summarizing what the documents say about it. Other functions, such as providing assistance and education to subscribers, are sometimes included in the traditional concept, but they receive relatively minor emphasis.

There is emerging a concept that might appropriately be called "national information system." In this concept, as it pertains to science and technology, there is (ideally) an arrangement for discovering and assessing the informational needs of users in a broad area and for adjusting the functions and actions of the various subsystems to meet those needs to an extent and in a way consistent with the national interest. A national library, a subsystem of a national information system, would differ in several ways from typical traditional libraries.

The national library would itself be a system of libraries, reaching from the local libraries and document rooms that make direct contact with the scientists, engineers, and technical administrators throughout the country to

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* This Appendix is submitted by the Chairman of the Panel; it does not purport to reflect consensus of the Panel.

central repositories and "correlatories." The national library would deal with information, knowledge, and communication quite as much as with documents and their circulation. The national library would be responsible for seeing to the satisfaction of such needs as indexing, abstracting, translation, and the preparation of bibliographies. In doing so, it would take advantage of existing resources (such as documentation centers, professional societies, and publishers), and particularly it would meld indexing, abstracting, and organization of knowledge (which are basic to retrieval of information and therefore to the successful operation of libraries) with the day-to-day work of substantive scientists and engineers (who, alone, have the understanding of their subject matter that is essential for useful indexing, abstracting, and organization). The national library would publish or ensure the publication of needed handbooks, abstract journals, and the like. The national library would engage in active dissemination of information, at first in an experimental way and later as a substantial service. The national library would supervise the assembly, organization , and dissemination of critical information in such areas as drug effects and epidemiology. Finally, the national library would, with the help of individuals and organizations, seek continually to improve its methods of assessing and meeting the informational needs of its domain.

Above all, according to the concept, the national library would exercise leadership and initiative to bring about effective interplay among the many individuals and diverse organizations engaged in interaction with its domain of

knowledge. That is a far cry, we recognize, from mere preservation and circulation of books, but it is an essential function that, in our opinion, greatly needs to be fulfilled. That function should be fulfilled, by all means, in the service of science, technology, and government in the national interest -- and not through any bureaucratic usurpation of functions that are substantively scientific or technical or specific to operating government agencies. However, it will not be fulfilled at a reasonably early date if its fulfillment is left to the initiative of scientists concerned with the discovery of new knowledge or to the initiative of individual government agencies interested in the exploitation of knowledge acquired under their sponsorship.